

These examples are for discussion purposes only - they are not intended as guidance and do not represent final decisions by Ecology on how ecological evaluations of soil contamination should be conducted.

The examples do not apply to sites that meet any of the Tier I off-ramps, where no further work is needed.

MTCA Soil Environmental Evaluation Process - Case Examples

Sites that do not qualify for a Tier 1 off-ramp must then be evaluated to see whether a Tier III evaluation is required¹ (“ecologically sensitive sites”), or whether a Tier II evaluation can be used. In most cases, a Tier III evaluation is not required, and a PLP can use either the Tier II or the Tier III evaluation procedures.

How the Tier II and Tier III approaches differ

Tier III is primarily intended for “ecologically sensitive sites”. It is a conservative approach, and Ecology and the PLP work together to decide on site-specific objectives of the evaluation, methods to be used, and how results from the evaluation will be used for remedial decisions. This approach is similar to that used in other states and by EPA, although there are some emphases based on Ecology’s past experience with ecological risk assessments:

- (i) Flexibility. A Tier III evaluation does not automatically require more work. For example, after reviewing what is known about the site, Ecology has the discretion to decide that:
 - Remediation plans based on other concerns (e.g., human health, groundwater protection) will also be ecologically protective, and no further work is needed².
 - There is already sufficient information to proceed with a remedial plan that will be ecologically protective³.
 - Although the site meets one of the criteria for requiring a Tier III evaluation, ecological concerns at the site are relatively low and the PLP may use Tier II screening numbers for remedial decisions.
- (ii) Streamlining the process. Data collection is not required unless there is a clear understanding between Ecology and the PLP as to how the information will be used for remedial decisions⁴.

¹ See preliminary draft rule language (6/24/97): 173-340-709(5)(b)

² As an example, if the containment of mine tailings to protect fish in an adjacent stream could also eliminate exposure pathways to terrestrial species, so a Tier III evaluation of terrestrial exposure pathways may not be needed.

³ This may apply, for example, where the area of contamination is well-defined (e.g. wastes buried in a trench), Ecology and the PLP agree on the need for removal, and there will be no residual contamination after the removal.

⁴ For example, although a site visit by Ecology staff is needed, an inventory of species and ecological communities is not automatically required. If the approach developed for the site includes a

- (iii) Consistent standards for the protection of wildlife at different sites. For sites where the evaluation focuses on protection of wildlife and food web modeling is used to make decisions, three common and widely distributed animals have been selected as standard indicator (or surrogate) species. Without this standardization, decisions based on wildlife protection can vary arbitrarily from site to site, depending on the species included in the model and the policy assumptions used in the model. Because the indicator species are at the high end of the risk range, decisions that are protective of these species are expected to be protective of other current or future terrestrial mammals and birds at the site. However, other species can be included on a site-specific basis if there is a special reason to do so (e.g., an endangered species is found at the site). Under the standardized approach, the model can be modified to reflect characteristics of the site that can be measured and are not expected to change, such as contaminant bioavailability.

Tier II is a less conservative, “cookbook” approach for use at less “ecologically sensitive” sites. Most sites that do not qualify for a Tier I off-ramp are expected to fall in this category. A primary objective in developing this approach is to provide more certainty as to what is required, without having to negotiate with Ecology at each step in the process. The development of this approach should therefore help to facilitate independent remedial actions. Cookbook components of this approach that can be used at any Tier II site include:

- Decision rules (offramps) for demonstrating that the soil contamination does not present a significant terrestrial ecological threat.
- A limited list of chemicals to consider (“Priority Contaminants of Ecological Concern”). It is not necessary to analyze the soil for each of these chemicals - only those that might be present, based on the past history of the site.
- Risk-based screening numbers are provided for each contaminant. The PLP has the choice of developing an alternative number for the site or using the default number for remedial decisions.
- Toolkit. Ecology will build a list of methods that can be used at any site to develop an alternative number. This does not mean that other methods cannot be used. A PLP can get assurance that decisions based on another method will be acceptable to Ecology by working with the department on a site-specific approach in a Tier III evaluation.

Possible outcomes of a Tier II evaluation include:

- The site qualifies for an off-ramp.
- No further work is required because the soil contamination does not involve a Priority Contaminant of Ecological Concern.
- No further work is required because Priority Contaminants of Ecological Concern at the site do not exceed Tier II screening levels.
- No additional remediation is required because more stringent standards (e.g., health-based numbers or groundwater protection numbers) will drive decisions.
- Remedial plans will be developed for meeting applicable Tier II screening numbers.
- The “toolkit” will be used to develop an alternative number (or to show that the contamination is not a problem).

biological survey, there should also be an understanding between Ecology and the PLP as to how this information will be used for remedial decisions.

- A Tier III evaluation will be used develop an alternative number (or to show that the contamination is not a problem).

The following examples are intended to illustrate possible approaches for conducting an ecological evaluation for soil contamination in cases where (1) the site does not need to go to Tier III, and (2) where a Tier III evaluation is required. These examples apply only to sites that do not qualify for a Tier I off-ramp.

In all of these examples, it is assumed that there is no contamination of surface water, sediments or wetlands at the site, so only a soil evaluation is needed.

Case 1. Copper and zinc contaminated soil. XYZ Site.

Tier II evaluation. Many sites that are evaluated with the Tier II approach may qualify for a Tier II offramp. For those that do not, this example illustrates how the evaluation might proceed.

Since no decision has yet been made on integration of Tier II screening numbers with Method A, it is assumed that this is a Method B cleanup and *groundwater protection is not a concern at the site*. The human health cleanup levels for copper and zinc are 2,960 ppm and 24,000 ppm, respectively. For unrestricted land use (i.e., not a commercial or industrial site), Tier II screening values for copper and zinc 140 ppm and 270 ppm, respectively.

The PLP has the following options:

- a) Extend the remediation plan to include soil contaminated above the Tier II screening values for copper and zinc.
- b) Develop an ecologically protective number for the site (depending on the outcome, the number may be higher or lower than the Tier II screening values).
- c) Conduct a Tier III evaluation with Ecology.

Option B scenario: The PLP decides not to use the Tier II copper and zinc screening numbers for remedial decisions. The Technical Analysis documents for copper and zinc (available on Ecology's Home Page) indicate that the relevant screening values are based on protection of plants and soil biota. To minimize the cost of the investigation, the PLP decides to test the most contaminated soil at the site with the plant and earthworm bioassays⁵. If this soil passes the tests the less contaminated soil can also be assumed to be acceptable, and no further testing will be needed.

Results: Duplicate plant and earthworm tests show that the most contaminated soil is toxic to both plants and soil biota, while no toxicity is found for a soil sample from an uncontaminated location nearby.

Based on these results, the PLP then considers two possibilities on how to proceed:

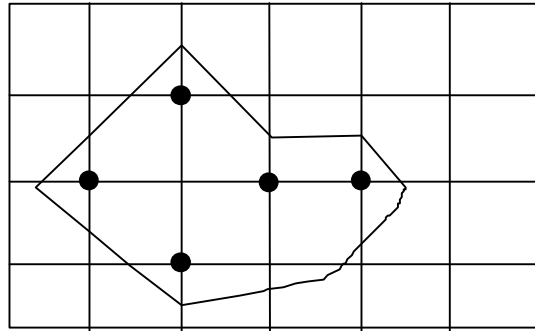
- (i) Test soil samples with different levels of contamination to find the highest concentrations that do not fail either of the two tests. These concentrations will then be used for remedial decisions.

⁵ Bioassays that are acceptable to Ecology when used at any Tier II site to develop a number that is protective of plants or soil biota are described in the following Ecology publications: *Early Seedling Growth Protocol for Soil Toxicity Screening*, Ecology Publication No. 96-324 and *Earthworm Bioassay Protocol for Soil Toxicity Screening*, Ecology Publication No. 96-327. Additional methods may be added in the future after being reviewed by Ecology. This does not mean that other methods cannot be used. A PLP who wishes to obtain preapproval of an alternative method before submitting a report to Ecology can consult with the department in a voluntary Tier III evaluation.

CASE 1: TIER II EVALUATION

- (ii) Use an “effects based approach” that does not require the development of numbers: Design a sampling grid over the contaminated area. Sampling points on the grid that fail either of the two tests will be used to define the area requiring remediation.

The PLP chooses the second approach. Results are shown below:



Case 1 example results. Remediation area based on sampling points failing the soil bioassays (solid circles). This is a hypothetical example - it is assumed that the study design was developed by the PLP. Bioassay testing is not a requirement and there are no requirements as to how many soil samples would need to be tested.

Case 2. Copper and zinc contaminated soil. Green Site.**“Involuntary” Tier III evaluation.**

A Tier III evaluation is required at this site because it met one of the criteria listed in 173-340-709⁶ (A “voluntary” evaluation means that the PLP chose to use the Tier III approach even though the site did not meet any of the criteria.) Initial decisions described below imply that Ecology is in agreement on each point.

- (1) There is no contamination of surface water, sediments or wetlands. Therefore only a terrestrial evaluation of soil contamination is needed.
- (2) The chemicals of potential ecological concern (COPECs) are copper and zinc.
- (3) Adequate soil sampling has been conducted, and no additional samples are needed to define the extent of the soil contamination or to be sure that no other contaminants have been missed.
- (4) A site visit is conducted with Ecology staff. Existing or potential exposure pathways at the site are identified as:
 - Soil ---> Soil biota
 - Soil ---> Plant life
 - Soil ---> Plant life ---> Wildlife
 - Soil ---> Soil biota ---> Wildlife

(5) Problem formulation:

Before proceeding, it is important to reach agreement with Ecology on the purpose and objectives of the Tier III evaluation. For the Green site, remediation to protect human health will leave some residual soil contamination at levels above the Tier III screening values for copper and zinc. What level of residual contamination is acceptable based on concerns for plants and soil biota? (These receptors were selected after reviewing the Tier II Technical Analysis documents. Plants and earthworms are more sensitive to the contaminants than wildlife.)

(6) Approach (see 173-340-709(5)(e)(iv)).

Various possible methods are available for evaluating soil contamination⁷. In discussions with Ecology, the following options are identified by the department and the PLP:

- (i) Use Ecology’s plant and earthworm bioassays to develop site-specific numbers for copper and zinc or to identify areas of soil toxicity requiring remediation (see Case 1).

⁶ See preliminary draft rule language (6/24/97): 173-340-709(5)(b)

⁷ Compendia of soil evaluation methods are available from several sources, including:

Linder, G. et al. *Evaluation of Terrestrial Indicators for Use in Ecological Assessments at Hazardous Waste Sites*. EPA/600/R-92/183

SETAC Short Course Notebooks. Titles vary, e.g.: *Soil and Plant Toxicity Assessment* (1991), *Assessing the Toxicity of Contaminated Soils* (1995).

Wentsel, R.A. et al. *Tri-Service Procedural Guidelines for Ecological Risk Assessments*. Vol. 1. May, 1996

CASE 2: TIER III EVALUATION

- (ii) Same as (i), except that the plant test will use a native species found near the site.
- (iii) The PLP suggests using the Tier II screening numbers for remedial decisions.
Because these are not conservative values, Ecology proposes testing some soil samples with contamination at or a little lower than the Tier II numbers. If these samples pass the bioassay tests, Ecology will agree to allow use of the Tier II numbers.
- (iv) Conduct a study to compare the abundance of earthworms in the contaminated area and in a reference area.

This is not intended to be an exhaustive list of possibilities. Some options, such as (iv), may need to include an up-front agreement between Ecology and the PLP not only on the study design, but also on decision rules on how results from the study will be used for remedial decisions.

After reviewing the options, the PLP decides on option (iii).

Results of the study are shown below:

Tier II screening levels:

Copper 140 ppm

Zinc 270 ppm

Soil sample	Bioassay results			
	Copper (ppm)	Zinc (ppm)	Earthworm	Plant
1	108	210	Pass	Fail
2	80	203	Pass	Pass
3	146	95	Pass	Pass
4	67	86	Fail	Pass
5	111	230	Pass	Pass

As these results illustrate, testing may not produce a clear cut answer. In general, contamination below the Tier II screening levels does not appear to be toxic to plants or soil biota. However, two “fail” results are obtained that have no clear relationship to the contaminant concentrations (e.g., the least contaminated sample failed one test). This illustrates the importance of an up-front agreement on decision rules. Assume that the following rule was agreed to:

At least two soil samples must fail both bioassays before the results are considered significant.

Based on this criterion, there is no significant evidence that the Tier II numbers would not be protective *at this site*. Ecology therefore agrees to allow the PLP to proceed with remedial decisions using the Tier II screening levels.

CASE 3: TIER II EVALUATION; “VOLUNTARY” TIER III EVALUATION**Case 3. Lead contaminated soil. ABZ Site.**

Tier II evaluation. In this example, it is assumed that the site does not meet any of the criteria requiring a Tier III evaluation, so the PLP has the option of going to either Tier II or Tier III. The Tier II approach is chosen. Many sites that are evaluated with the Tier II approach may qualify for a Tier II offramp. For those that do not, this example illustrates how the evaluation might proceed.

(1) The soil is contaminated with xylene and lead. Since xylene is not a Tier II Priority Contaminant of Ecological Concern, only lead needs to be considered. The soil contamination does exceed the Tier II eco-screening level for lead (220 ppm). If the contamination had been below 220 ppm, the site would qualified for an offramp on this basis.

(2) The PLP has the following options:

- a) Proceed with a remediation plan that will comply with the 220 ppm criterion for lead. A PLP may decide to do this because, for example, a similar (or more stringent) cleanup objective is also required for other reasons, such as human health concerns. Or it may be preferable to proceed with a cleanup based on the 220 ppm criterion rather than spending additional time and effort to develop an alternative ecological number.
- b) Go to Tier III (this scenario is discussed below).
- c) Develop an ecologically protective number for the site (depending on the outcome, the number may be higher or lower than 220 ppm).

Option C: The Technical Analysis document for lead (available on Ecology’s Home Page) indicates that the 220 ppm screening value is based on protection of wildlife (birds). Ecology has not preapproved a method for use at any Tier II site to develop a soil concentration protective of wildlife⁸. A PLP who wishes to obtain preapproval will need to consult with Ecology in a Tier III evaluation (see below).

Voluntary Tier III evaluation⁹. The PLP has decided to go from Tier II to Tier III. Since the ABZ site did not meet any of the criteria *requiring* a Tier III approach (173-340-709(5(b))), this is a “voluntary Tier III evaluation”.

The Tier III approach is less “cookbook” than the Tier II approach, and requires close collaboration with Ecology staff in deciding how to proceed. The initial decisions described below imply that Ecology is in agreement on each point.

⁸ See footnote 4.

⁹ Where a PLP elects to conduct a Tier III evaluation even though a site does not meet any of the criteria where a Tier III is required, this is a “voluntary” Tier III evaluation. In an *voluntary* evaluation, the assessment is limited to the Tier II Priority Contaminants of Ecological Concern (Table 5 of 173-340-709). In an *involuntary* evaluation, there is no restriction on the chemicals that may be identified as site-specific COPECs.

CASE 3: TIER II EVALUATION; "VOLUNTARY" TIER III EVALUATION

- (1) There is no contamination of surface water, sediments or wetlands. Therefore only a terrestrial evaluation of soil contamination is needed.
- (2) The only chemical of potential ecological concern (COPEC) is lead, since it is a Tier II Priority Contaminant of Ecological Concern and exceeds the Tier II screening level¹⁰.
- (3) Adequate soil sampling has been conducted, and no additional samples are needed to define the extent of the soil contamination or to be sure that no other contaminants have been missed.
- (4) A site visit is conducted with Ecology staff. Existing or potential exposure pathways at the site are identified as:

Soil ---> Soil biota
Soil ---> Plant life
Soil ---> Plant life ---> Wildlife
Soil ---> Soil biota ---> Wildlife

(5) **Problem formulation:**

Before proceeding, it is important to reach agreement with Ecology on the purpose and objectives of the Tier III evaluation. For the ABZ site, remediation to protect human health will leave some residual soil contamination at levels above the 220 ppm Tier II screening value for lead. What level of residual contamination is acceptable based on concerns for wildlife? (Wildlife was selected after reviewing the Tier II Technical Analysis document for lead. The Tier II screening value is based on risks to wildlife.)

(6) **Approach** (see 173-340-709(5)(e)(iv)).

Various possible methods are available for evaluating soil contamination¹¹. The PLP proposes to use the food web modeling approach. Since the residual soil contamination exceeds the lead value calculated with the Level 1 screening model (115 ppm), the PLP proposes to use site-specific information to modify the model (Level 2 analysis). Available options are:

- (i) Develop site-specific toxicity reference values (TRVs) from the literature. The most stringent soil concentration for lead from the Level 1 model is the value based on protection of birds. The Level 1 avian TRV is based on a study using lead acetate (Ecology lead Technical Analysis document). Since the site is contaminated with lead sulfate, an avian TRV for lead sulfate could be developed from the literature for use with the model.
- (ii) Develop a site-specific avian gut absorption factor (GAF) or an avian GAF for lead sulfate from the literature.
- (iii) Develop a site-specific bioaccumulation factor (BAF) or a BAF for lead sulfate from the literature. (The BAF in the model is for uptake by soil biota that are fed on by wildlife, using earthworms as a surrogate species.)

¹⁰ This approach applies because this is a "voluntary" Tier III evaluation. For an "involuntary Tier III evaluation" - where a site meets one of the criteria for *requiring* a Tier III evaluation - a different approach is used to identify the chemicals of ecological concern. The approach is described in 173-340-709(5)(e)(iii). See footnote 9.

¹¹ Compendia of soil evaluation methods are available from various sources, including:

Linder, G. et al. *Evaluation of Terrestrial Indicators for Use in Ecological Assessments at Hazardous Waste Sites*. EPA/600/R-92/183

SETAC Short Course Notebooks. Titles vary, e.g.: *Soil and Plant Toxicity Assessment* (1991), *Assessing the Toxicity of Contaminated Soils* (1995).

Wentzel, R.A. et al. *Tri-Service Procedural Guidelines for Ecological Risk Assessments*. Vol. 1. May, 1996

CASE 3: TIER II EVALUATION; "VOLUNTARY" TIER III EVALUATION

The PLP elects to develop a site-specific BAF. (Note that more than one of the options i - iii listed above can be chosen.) There are at least two ways to calculate a BAF:

- (i) Using measurements from soil and soil biota collected at the site. A partial bibliography for this method is included.
- (ii) By adding soil biota (worms) to soil collected from the site, and later measuring the lead concentration in the worms.

The PLP proposes to use the first method, which yields the following results:

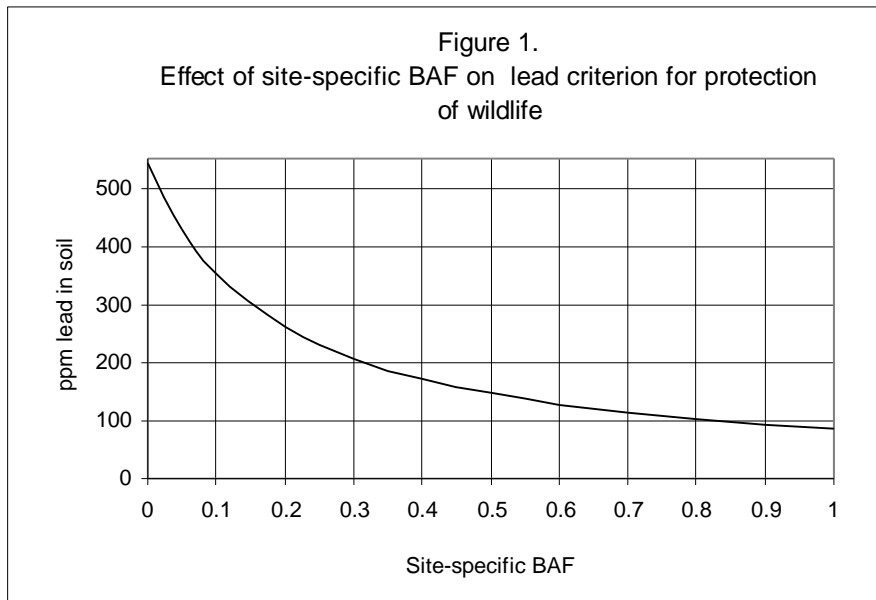
Average lead concentration in earthworms: 65 mg/kg (dry weight basis)

Average soil concentration: 325 mg/kg

Calculated BAF = $65/325 = 0.2$

(Other methods could also be used to calculate a BAF from the sampling data. As with most aspects of a Tier III evaluation, this is an issue that should be discussed with Ecology.)

Using the empirical, site-specific BAF (0.2) in the MTCA Tier III food web model yields an acceptable soil concentration of 262 ppm. Figure 1 shows how the lead soil concentration calculated from the Tier III model varies depending on the site-specific BAF.



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